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Information in support of a Recovery Potential Assessment of Pugnose Minnow (*Opsopoeodus emiliae*) in Canada

Information à l'appui de l'évaluation du potentiel de rétablissement du petit-bec (*Opsopoeodus emiliae*) au Canada

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TABLE OF CONTENTS

ABSTRACT iv
RÉSUMÉ v
SPECIES INFORMATION 1
BACKGROUND 1
CURRENT STATUS 3
POPULATION STATUS ASSESSMENT 6
HABITAT REQUIREMENTS 8
THREATS 12
THREAT LEVEL ASSESSMENT 16
MITIGATIONS AND ALTERNATIVES 19
SOURCES OF UNCERTAINTY 23
REFERENCES 24

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ABSTRACT

In April 1985, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the status of Pugnose Minnow (*Opsopoeodus emiliae*) and determined the designation to be Special Concern. In May 2000, the status was re-examined and confirmed by COSEWIC. The status was re-assessed in May 2012 at which time Pugnose Minnow was designated as Threatened. The reason provided for this designation is that, "This fish is a small-bodied species with a restricted and declining distribution that inhabits river, stream and lake habitats. The species is threatened by habitat loss, habitat degradation from nutrient and sediment loading, climate change and several invasive species. The overall level of threat has been assessed as high." Pugnose Minnow is currently listed as Special Concern on Schedule 1 of the *Species at Risk Act* (SARA).

The Recovery Potential Assessment (RPA) provides information and scientific advice needed to fulfill various requirements of SARA, including informing both scientific and socio-economic elements of the listing decision and permitting activities that would otherwise violate SARA prohibitions and the development of recovery strategies. This Research Document describes the current state of knowledge of the biology, ecology, distribution, population trends, habitat requirements, and threats to Pugnose Minnow. Mitigation measures and alternative activities related to the identified threats, which can be used to protect the species, are also presented. The information contained in the RPA and this document may be used to inform the development of recovery documents and for assessing permits, agreements and related conditions, as per section 73, 74, 75, 77 and 78 of SARA. The scientific information also serves as advice to the Minister of Fisheries and Oceans Canada regarding the listing of the species under SARA and is used when analyzing the socio-economic impacts of adding the species to the list as well as during subsequent consultations, where applicable. This assessment considers the available scientific data with which to assess the recovery potential of Pugnose Minnow in Canada.

RÉSUMÉ

En avril 1985, le Comité sur la situation des espèces en péril au Canada (COSEPAC) a évalué la situation du petit-bec (*Opsopoeodus emiliae*) et lui a accordé le statut d'espèce préoccupante. En mai 2000, le COSEPAC a réexaminé ce statut et l'a confirmé. Lors d'un nouvel examen effectué en mai 2012, il a désigné le petit-bec en tant qu'espèce menacée. La désignation a été justifiée par le fait que « ce poisson de petite taille a une répartition limitée et en déclin et habite les habitats de rivières, de ruisseaux et de lacs. L'espèce est menacée par la perte ainsi que la dégradation de son habitat en raison de l'apport de sédiments et d'éléments nutritifs, les changements climatiques et plusieurs espèces exotiques. Le niveau de menace global a été évalué comme étant élevé. » À l'heure actuelle, l'espèce est inscrite comme espèce préoccupante à l'annexe 1 de la *Loi sur les espèces en péril* (LEP).

L'évaluation du potentiel de rétablissement (EPR) fournit les renseignements et les avis scientifiques nécessaires pour satisfaire à diverses exigences de la LEP; notamment, cette évaluation permet d'éclairer les aspects scientifiques et socioéconomiques de la décision relative à l'inscription à la liste, de réaliser des activités qui autrement enfreindraient les interdictions de la LEP et d'élaborer des stratégies de rétablissement. Le présent document de recherche fournit une description de l'état actuel de la biologie, de l'écologie, de la distribution, des tendances de la population, des besoins en matière d'habitat et des menaces relatives au petit-bec. Des mesures d'atténuation et des activités alternatives associées aux menaces déterminées, qui peuvent être utilisées dans le but de protéger l'espèce, sont également présentées. Les renseignements que renferment l'EPR et ce document peuvent servir de base à l'élaboration de documents relatifs au rétablissement et à l'évaluation des permis, des ententes et des conditions s'y rattachant, conformément aux articles 73, 74, 75, 77 et 78 de la LEP. L'information scientifique sert aussi d'avis au ministre des Pêches et des Océans concernant l'inscription de l'espèce à la liste de la LEP et est utilisée au moment d'analyser les répercussions socio-économiques de l'inscription de l'espèce et pendant les séances de consultations subséquentes, le cas échéant. Cette évaluation tient compte de toutes les données scientifiques existantes pour évaluer le potentiel de rétablissement du petit-bec au Canada.

SPECIES INFORMATION

Scientific Name – *Opsopoeodus emiliae* (Hay, 1881)
Common Name – Pugnose Minnow
Current COSEWIC Status (Year of Designation) – Threatened (2012)
COSEWIC Reason for Designation[1] – This fish is a small-bodied species with a restricted and declining distribution that inhabits river, stream and lake habitats. The species is threatened by habitat loss, habitat degradation from nutrient and sediment loading, climate change and several exotic species. The overall level of threat has been assessed as high.
Current *Species at Risk Act* Status (Schedule) – Special Concern (Schedule 1)
Current Ontario *Endangered Species Act* Status (Year of Designation) – Special Concern
Range in Canada – Ontario

BACKGROUND

DESIGNATION

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the status of Pugnose Minnow (*Opsopoeodus emiliae*) in April 1985 as Special Concern. This status was re-assessed and confirmed as Special Concern in May 2000. When re-examined in May 2012, Pugnose Minnow status was changed to Threatened. The reason given for this designation was that, "This fish is a small-bodied species with a restricted and declining distribution that inhabits river, stream and lake habitats. The species is threatened by habitat loss, habitat degradation from nutrient and sediment loading, climate change and several exotic species. The overall level of threat has been assessed as high." Subsequent to the original COSEWIC designation, Pugnose Minnow was listed on Schedule 1 of the *Species at Risk Act* (SARA) in June 2004. Pugnose Minnow is currently listed as Special Concern on Schedule 1. A Recovery Potential Assessment (RPA) process has been developed by Fisheries and Oceans Canada (DFO) to provide information and scientific advice needed to fulfill SARA requirements, including the development of recovery strategies and authorizations to carry out activities that would otherwise violate SARA (DFO 2007). This document provides background information on Pugnose Minnow to inform the RPA.

SPECIES DESCRIPTION

Pugnose Minnow is a small, slightly deep-bodied, silver fish that reaches an average maximum total length (TL) in Ontario of approximately 5 cm, and does not exceed 6.4 cm (Holm et al. 2010; Figure 1). The most distinct characteristics of Pugnose Minnow are a rounded snout, a very small, steeply upturned mouth, and a pale lower lip (Holm et al. 2010). Pugnose Minnow has large scales (35-41 lateral scales) and a dorsal fin with 9 dorsal rays (Holm et al. 2010). Coloration includes a white belly, a pale yellow to olive green back, a prominent lateral stripe that starts at the snout and ends in a spot at the base of the caudal fin, and darkly outlined scales which give the appearance of a cross-hatched pattern (Holm et al. 2010). Spawning males tend to have a darker dorsal fin, and the lower half of the anal fin is bright white (Holm et al. 2010). Spawning males may also have stubble-like nuptial tubercles on their snout, lips, and chin (Holm et al. 2010).

[1] http://www.cosewic.gc.ca/eng

*Figure 1. Pugnose Minnow (*Opsopoeodus emiliae*). Illustration by Joe Tomelleri, reproduced with permission.*

Pugnose Minnow is morphologically similar to other minnows, primarily Golden Shiner (*Notemigonus crysoleucas*) and Pugnose Shiner (*Notropis anogenus*). Golden Shiner may be distinguished from Pugnose Minnow by having a body that is deeper and thinner from side to side, and large anal fin with more than 11 rays (Holm et al. 2010). Characteristics used to distinguish Pugnose Shiner from Pugnose Minnow include a dark lower lip, a dorsal fin with 8 fin rays, and non-outlined scales that do not form a cross-hatched pattern (Holm et al. 2010).

GROWTH AND REPRODUCTION

Scales were collected from Pugnose Minnow captured by Parker et al. (1987), age interpretation was attempted, and age was estimated to be three years. Parker et al. (1987) noted that annuli were apparent on the scales; however, validation of the scale method for this species is required for proper age interpretation. Age of maturation is unknown but it is believed to be reached within the first year, as is common for other similar cyprinids (Boschung and Mayden 2004). Potential for hybridization, population size structure and sex ratios are unknown for this species (COSEWIC 2012).

DIET

Pugnose Minnow has been noted in the literature to feed primarily on insect larvae, filamentous algae, and microcrustaceans (Etnier and Starnes 1993; Holm et al. 2010). This dietary description would appear to compliment the species' upturned mouth. A gut content analysis noted the presence of adult Diptera and larval Trichoptera in the stomach of Pugnose Minnow in Ontario, while gut contents of specimens collected from Florida consisted of chironomid larvae, filamentous algae, small crustaceans, larval fishes, and fish eggs (COSEWIC 2012).

DISTIBUTION

Pugnose Minnow occurs only in North America where it is widely distributed in the east-central United States, primarily in Louisiana, Mississippi, Alabama, and Tennessee, where it is considered 'Secure' (NatureServe 2012). Other states in which it is found include Texas, Oklahoma, Arkansas, Georgia, Florida, Missouri, Iowa, Minnesota, Kentucky, Indiana, Illinois, and Wisconsin (NatureServe 2012). It is considered 'Imperiled' or 'Critically Imperiled' in Michigan, Ohio, and Pennsylvania (NatureServe 2012). In Canada, Pugnose Minnow has a highly restricted distribution that includes tributaries of Lake St. Clair, Lake St. Clair proper, and

the Detroit River. The earliest record of Pugnose Minnow in Canada is a voucher specimen recorded from Mitchell's Bay in Lake St. Clair in 1935 (ROM Accession: 08956). The limited range of Pugnose Minnow in Canada represents less than 5% of the global range for this species (Edwards and Staton 2009).

CURRENT STATUS

In Canada, current Pugnose Minnow distribution is restricted to southwestern Ontario where it is found in the Detroit River, Lake St. Clair proper, as well as tributaries of Lake St. Clair (Figure 2). Tributaries of Lake St. Clair include Sydenham River (north and east branches), Bear Creek (a tributary of north Sydenham River), East Otter Creek (a tributary of east Sydenham River), Chenail Ecarte (a man-made connecting channel between St. Clair River and Lake St. Clair), and Little Bear Creek, Maxwell Creek, and Whitebread Drain, which all flow into the Chenail Ecarte.

Historically, Pugnose Minnow was present in both the Thames River and McDougall Drain (a tributary of the Thames River). Currently, Pugnose Minnow is considered extirpated from the Thames River and likely extirpated from McDougall Drain (COSEWIC 2012). The loss of these two populations has dramatically affected the distribution of this species resulting in a 87% decline in the extent of occurrence (COSEWIC 2012). The current area of occupancy, based on a 2 x 2 km grid, is 84 km² and when compared to the historic calculated area of occupancy (276 km²), represents a 69% decline for this species (COSEWIC 2012).

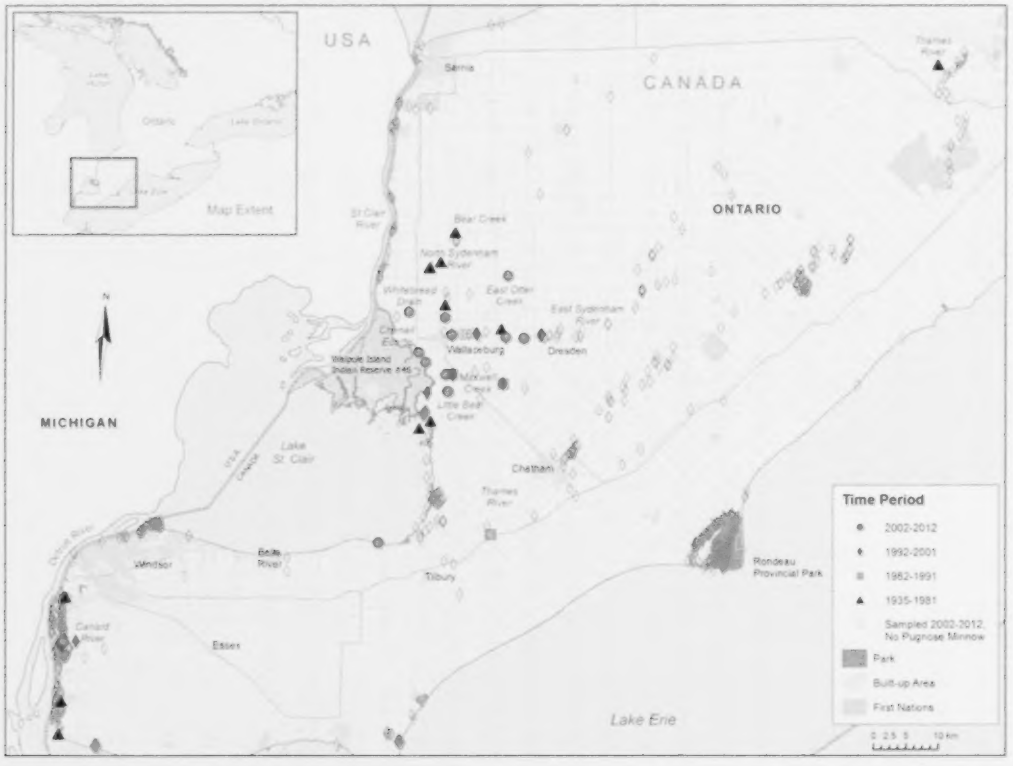

Figure 2. Distribution of Pugnose Minnow in Canada.

DETROIT RIVER

Pugnose Minnow was originally captured in the Detroit River near Fighting Island in 1940 (University of Michigan Museum of Zoology Catalogue Number 130863), consisting of two voucher specimens. Three additional voucher specimens were collected from this area in 1941 [Royal Ontario Museum (ROM) 14703]. In 1994-1996, the ROM surveyed this area and confirmed the presence of Pugnose Minnow in the Detroit River. Additionally, in 1994, Leslie and Timmins (2002) captured 28 individuals from the Canard River (a tributary of the Detroit River). These vouchers were verified to be Pugnose Minnow by the ROM in 2001 (ROM 72287). More recent collections (Lapointe 2005) confirmed the presence of Pugnose Minnow in this area with the collection of a single individual. Lapointe (2005) recorded two additional Pugnose Minnow from his surveys but voucher specimens were not collected; therefore, these two individuals are not considered during the population status assessment. It should be noted that Lapointe (2005) intensively sampled the Detroit River in 2003 and 2004, at numerous sites, with multiple gear types and captured a single individual. This would lead us to believe that Pugnose Minnow, although present in the Detroit River, are very rare.

LAKE ST. CLAIR AND TRIBUTARIES

Lake St. Clair

The first record of Pugnose Minnow in Canada originates from Mitchell's Bay in Lake St. Clair in 1935 when two individuals were captured (ROM 08956). Since this initial record, only three additional individuals have been captured from Lake St. Clair proper. Two additional individuals were captured from Mitchell's Bay near the location of the original capture in 1979 (ROM 37581), while a third individual was captured from the south shore of Lake St. Clair in 2007 [G. Yunker, Ontario Ministry of Natural Resources (OMNR), unpubl. data].

Comprehensive sampling has occurred on Walpole Island (Metsger and Holm 2000 as cited in COSEWIC 2012), the nearshore area of Mitchell's Bay (Bouvier 2006), St. Clair National Wildlife Area (Bouvier 2006; (Bouvier 2006; Marson et al. 2010), and the south shore of Lake St. Clair (Megan Belore, OMNR, pers. comm.). Although these surveys did not exclusively use seine nets (the sampling technique commonly thought to be most effective at capturing Pugnose Minnow), Pugnose Minnow was not recorded from any of these surveys.

Sydenham River

North Sydenham River

Historically, Pugnose Minnow was first recorded from the Sydenham River in 1972 (ROM 720199) approximately 12.1 km north of Wallaceburg. Again, Pugnose Minnow was recorded from the North Sydenham River in 1978 (ROM 45298) and 1979 (ROM 791051). The two sites of capture were 5.5 km and 10 km north of Wallaceburg. The most recent Pugnose Minnow record from the North Sydenham River dates to 2003 when a single Pugnose Minnow was captured by backpack electrofisher (Mandrak et al. 2006). Attempts to capture Pugnose Minnow were made in 2010 when six sites were seined (DFO, unpubl. data). Unfortunately, none of these attempts resulted in the capture of Pugnose Minnow.

East Sydenham River

Pugnose Minnow was first recorded from the East Sydenham River in 1979 (ROM 791154). Subsequent years of capture include 1997 (n=17; ROM 70780, ROM 70973, ROM 70975),

2001 (n=1; ROM 72608) and 2003 (n=3; DFO, unpubl. data). More recently, 21 Pugnose Minnow were captured during targeted sampling in 2010 at five sites in the lower portion of the Sydenham River (DFO, unpubl. data). It should be noted that although the status report (COSEWIC 2012) reported the capture of 22 individuals, following verification of voucher specimens one of the vouchers was determined to be un-identifiable.

A total of 75 wadeable sites were sampling from 2003 to 2004 throughout the Sydenham River basin (north, and east branches) using multiple gear types (backpack electrofisher, seine, minnow trap, and Windermere trap) (Poos 2004). This intensive sampling did not yield the capture of any Pugnose Minnow.

Bear Creek

A single Pugnose Minnow voucher has been collected from Bear Creek (ROM 791206). The voucher was collected 100 m upstream from the confluence of Bear Creek and North Sydenham River. This is the only record of Pugnose Minnow from this tributary of the North Sydenham River.

East Otter Creek

A single Pugnose Minnow record exists (Mandrak et al. 2006) for East Otter Creek (a tributary of the Sydenham River). The site was revisited and sampled in 2010 but no additional Pugnose Minnow were captured.

Chenail Ecarte

A total of five Pugnose Minnow have been captured from the Chenail Ecarte, a man-made connecting channel between St. Clair River and Lake St. Clair. The first record was represented by the capture of a single individual in 1993 (ROM 67792). An additional four individuals were captured from two sites in 2010 (DFO, unpubl. data).

Maxwell Creek

Pugnose Minnow was initially recorded from Maxwell Creek (a tributary to Lake St. Clair) in 1974 (n=24; ROM 30511). Unfortunately, the coordinates recorded with the voucher specimens were incorrect and the exact location of capture could not be determined. Additional voucher specimens were taken from Maxwell Creek in 1982 (n=1; ROM 42359), 1996 (n=2; ROM 70291), and in 2003 (n=2; DFO, unpubl. data). Although the capture of Pugnose Minnow in 2010 was reported in the COSEWIC status report (COSEWIC 2012), this voucher specimen was verified to be Pugnose Shiner.

Little Bear Creek

Pugnose Minnow has been recorded from Little Bear Creek since 1982 (n=1; ROM 51247). One additional individual was captured in 1996 (ROM 70289). In 2003, three individuals were recorded from four sites sampled by seine net (Mandrak et al. 2006). The site was re-visited in 2010 and an additional 11 individuals were recorded and verified (DFO, unpubl. data). A slight correction should be made in the number of individuals captured reported in the COSEWIC status report (COSEWIC 2012), in that four of the 15 individuals originally reported were later verified to be Blacknose Shiner (*Notropis heterolepis*)(DFO, unpubl. data).

Whitebread Drain

Pugnose Minnow was first observed in Whitebread Drain (a small agricultural drain, which drains directly into the Chenail Ecarte) in 2003 (Mandrak et al. 2006). The site was re-visited in 2010 and sampled with appropriate gear in search for additional individuals (DFO, unpubl. data). No Pugnose Minnow were recorded from a single seine event (DFO, unpubl. data).

MCDOUGALL DRAIN (LIKELY EXTIRPATED)

Pugnose Minnow has also been recorded from a tributary to the Thames River, McDougall Drain. Two individuals were captured from McDougall Drain in 1984 (ROM 46162). McDougall Drain was re-visited in 2004 and Pugnose Minnow targeted sampling was undertaken (DFO, unpubl. data). This targeted sampling did not result in the capture of any additional individuals. In addition a single site was sampled in 2004 by the Upper Thames Region Conservation Authority and did not yield the capture of any Pugnose Minnow (COSEWIC 2012).

THAMES RIVER (EXTIRPATED)

Seven Pugnose Minnow voucher specimens originate from the Thames River. These vouchers were captured in 1968 near Delaware (ROM 26480). Additional sampling, including sampling targeting Pugnose Minnow, has occurred since 1968 in the vicinity of the original capture location but has not resulted in the capture of additional individuals (refer to COSEWIC 2012 for a detailed description of failed sampling attempts). A lack of Pugnose Minnow captures despite substantial effort using the appropriate gear in habitats thought to be preferred by Pugnose Minnow leads us to believe that Pugnose Minnow is extirpated from the Thames River.

POPULATION STATUS ASSESSMENT

To assess the population status of Pugnose Minnow in Canada, each population was ranked in terms of its abundance and trajectory (Table 1). The method used in prior Recovery Potential Assessments included the ranking of each population in terms of a Relative Abundance Index, in which each population was ranked relative to the most abundant population. We are unable to determine a relative abundance for Pugnose Minnow as we are only considering two populations; Detroit River and Lake St. Clair and its tributaries. For the purposes of the RPA, Lake St. Clair and its tributaries are considered a single population. This determination follows the RPA definition of a population, in that if no barriers to movement exist, if there is similar or continuous occupied habitat connecting the two locations, and the species could conceivably move from one location to another, these individuals are considered to be a part of a single population.

Although it was not possible to assign a Relative Abundance Index to each population, each population was assigned an Abundance Index. The Abundance Index was assigned as Extirpated, Likely Extirpated, Low, Medium, High or Unknown. Sampling parameters, such as gear used, area sampled, sampling effort, and whether the study targeted Pugnose Minnow, were considered. The number of individual Pugnose Minnow caught during each sampling period was also considered when assigning the Abundance Index.

The Population Trajectory was assessed as Decreasing, Stable, Increasing, or Unknown for each population based on the best available information about the current trajectory of the population. The number of individuals caught over time for each population was considered. Trends over time were classified as Increasing (an increase in abundance over time),

Decreasing (a decrease in abundance over time), and Stable (no change in abundance over time). If insufficient information was available to identify the trajectory, the Population Trajectory was listed as Unknown. Certainty has been associated with the Abundance Index and Population Trajectory rankings and is listed as: 1=quantitative analysis; 2=CPUE or standardized sampling; 3=expert opinion (Table 1).

Table 1. Abundance Index and Population Trajectory of each Pugnose Minnow population in Canada. Certainty has been associated with the Abundance Index, and Population Trajectory rankings and is listed as: 1=quantitative analysis; 2=CPUE or standardized sampling; 3=expert opinion.

Population	Abundance Index	Certainty	Population Trajectory	Certainty
Detroit River	Low	2	Decreasing	3
Lake St. Clair and tributaries	Medium	2	Decreasing	3
McDougall Drain	Likely extirpated	2	Not applicable	
Thames River	Extirpated	2	Not applicable	

The Abundance Index and Population Trajectory values were then combined in the Population Status matrix (Table 2) to determine the Population Status for each population. Each Population Status is subsequently ranked as Extirpated, Likely Extirpated, Poor, Fair, Good, Unknown or Not applicable (Table 3). Certainty assigned to each Population Status is reflective of the lowest level of certainty associated with either initial parameter (Abundance Index, or Population Trajectory).

Table 2. The Population Status Matrix combines the Abundance Index and Population Trajectory rankings to establish the Population Status for each Pugnose Minnow population in Canada. The resulting Population Status has been categorized as Extirpated, Likely Extirpated, Poor, Fair, Good, or Unknown.

		Population Trajectory			
		Increasing	**Stable**	**Decreasing**	**Unknown**
Abundance Index	**Low**	Poor	Poor	Poor	Poor
	Medium	Fair	Fair	Poor	Poor
	High	Good	Good	Fair	Fair
	Unknown	Unknown	Unknown	Unknown	Unknown
	Likely Extirpated	Likely extirpated	Likely extirpated	Likely Extirpated	Likely extirpated
	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated

Table 3. Population Status of all Pugnose Minnow populations in Canada, resulting from an analysis of both the Abundance Index and Population Trajectory. Certainty assigned to each Population Status is reflective of the lowest level of certainty associated with either initial parameter (Abundance Index, or Population Trajectory).

Population	Population Status	Certainty
Detroit River	Poor	3
Lake St. Clair and tributaries	Poor	3
McDougall Drain	Likely extirpated	2
Thames River	Extirpated	2

HABITAT REQUIREMENTS

SPAWNING

Spawning habitat preferences and spawning behavior of Canadian populations of Pugnose Minnow are not known. Spawning season has been recorded for Pugnose Minnow in Florida (late winter into late summer; McLane 1955), Illinois (spawning fish collected in May and June; Gilbert and Bailey 1972), Missouri (fish caught in spawning condition late-May to June; Pflieger 1997), and Texas (May to June; Moriarty and Winemiller 1997). Based on specimen size, it has been suggested that the spawning season in Texas may begin as early as February (Edwards 1997 in Thomas et al. 2007). It is difficult to infer the spawning season for Canadian populations of Pugnose Minnow based on this information, but there is general agreement that spawning likely occurs in the spring (May to June; Holm et al. 2010). There is a record of a single pre-spawn female captured from an unnamed drain to Mitchell's Bay on June 2, 1979 when water temperature was recorded to be 21°C (COSEWIC 2012).

Spawning has been observed in a laboratory setting with fish collected from creeks in Louisiana and Alabama (Page and Johnston 1990). The following is a synopsis of the spawning behaviour observed during Page and Johnston's (1990) aquaria-based spawning experiment. Aquarium were set up with substrate known to be used for spawning by North American minnows (i.e., sand, fine gravel, coarse gravel), as well as vegetation, logs, and rocks ranging in size from boulders to a piece of slab. In all experiments (n=2), a dominant male selected the underside of a large rock as the spawning surface. The male prepared the site for egg deposition, and a total of 87 spawning acts were observed. Males selectively chose the underside of a large rock, although many other potential spawning surfaces were readily available indicating a preference to this type of substrate for spawning. Eggs were collected in placed in holding containers with various water temperatures. All eggs held at 11, 16, and 29°C died, while all eggs held at 21, 25, and 27°C hatched, indicating a likely temperature range preference for egg hatching 21-27°C. Newly hatched larvae were 5-5.5 mm in length (total or standard length was not specified).

JUVENILE

There is very limited information available on habitat preferences of juvenile Pugnose Minnow. Limited data on juvenile Pugnose Minnow habitat requirements necessitate the inference of these requirements from other, better-studied, life stages.

ADULT

Very little information is available regarding the habitat requirements of Pugnose Minnow in Canada. The first detailed description of habitat from the point of capture of Pugnose Minnow in Canada was provided by Parker and McKee (1980). Data recorded with vouchers captured from the North Sydenham River during this survey described habitat as pond-like, weedy embayments along the river's edges (Parker and McKee 1980). Water depth was recorded between 0.5 and 1.5 m, and a high level of suspended solids, resulting in a maximum Secchi disc transparency of approximately 10 cm, was noted from all capture locations (Parker and McKee 1980). During this September survey, Pugnose Minnow was captured when water temperatures ranged from 17.5 to 19°C, and dissolved oxygen concentrations were approximately 7 mg/L (Parker and McKee 1980). Capture locations in Mitchell's Bay (embayment of Lake St. Clair) varied slightly, in that aquatic vegetation was present, and heavy growth of spatterdock (*Nuphar* sp.) was noted at several sites of capture (Parker and McKee 1980). It was also noted that water transparency was higher in Mitchell's Bay, although values

were not provided (Parker and McKee 1980). Parker et al. (1987) concluded that the high turbidity at capture sites during the 1979 survey of Parker and McKee (1980) suggested that the North Sydenham River system may provide only marginal habitat for this species, and that Mitchell Bay may provide a more favourable habitat.

Pugnose Minnow vouchers captured during surveys completed by the ROM in 1996-1997 include descriptions of habitat characteristics similar to Parker et al. (1987). Secchi depth at points of capture ranged from 0.1 – 0.3 m and substrate composition was described as silt, muck and detritus with some cover of boulders, woody debris, and aquatic vegetation (COSEWIC 2012).

Habitat information at point of capture was available for all 2003 (n=28) and 2010 (n=36) DFO records. Pugnose Minnow was captured in relatively shallow water with depth ranging from 0.42 to 1.34 m. Pugnose Minnow was also captured from environments exhibiting a broad spectrum of water temperature, ranging from 13.9 to 29.0°C. Turbidity was measured with either a Secchi disc (readings ranged from 0.28 to 1.8 m; mean=0.58 m) or turbidity tube (readings ranged from 0.22 to 0.64 m; mean=0.41 m). The majority of sites were classified as having a silt/clay-dominant substrate. Most sites were also classified as being dominated by open water (n=8), while sites dominated by submergent (n=5) or floating (n=2) macrophytes were also quite common. This association with open water-dominated habitat is contrary to most published literature suggesting a strong relationship between Pugnose Minnow and high macrophyte abundance. However, specimens recorded from Chenail Ecarte and Detroit River were associated with areas with abundant vegetation.

Although this species has been historically described as preferring clear, slow-moving, heavily-vegetated habitat (Gilbert and Bailey 1972; Scott and Crossman 1973; Trautman 1981), currently Pugnose Minnow in Canada are most often found in warm, slow moving areas of turbid streams with little to no aquatic vegetation, over silt/clay substrates or slow moving side channels of larger rivers with abundant vegetation. Trautman (1981) describes the contradictory habitat characteristics for Ohio populations of Pugnose Minnow. Relict Pugnose Minnow populations persisted in Ohio for several years after almost all of the aquatic vegetation had disappeared, and after turbidity levels and siltation had become high. He believed that small populations may persist for some time in submarginal conditions when preferred habitat is no longer available. This persistence in areas of sub-optimal habitat may describe the current state of Pugnose Minnow in Canada and may also explain the few individuals captured despite targeted sampling efforts.

FUNCTIONS, FEATURES AND ATTRIBUTES

A description of the functions, features, and attributes associated with Pugnose Minnow habitat can be found in Table 4. The habitat required for each life stage has been assigned a function that corresponds to a biological requirement of Pugnose Minnow. For example, individuals in the spawning life stage require habitat for nursery and spawning purposes. In addition to the habitat function, a feature has been assigned to each life stage. A feature is considered to be the structural component of the habitat necessary for the survival or recovery of the species. Habitat attributes have also been provided, which describe how the features support the function for each life stage. Optimal habitat attributes from the literature for each life stage have been combined with habitat attributes from current records (records from 2002 to present) to show the maximum range in habitat attributes within which Pugnose Minnow may be found (see Table 4, and references therein). This information is provided to guide any future identification of critical habitat for this species. It should be noted that habitat attributes associated with current

Table 4. The following table summarizes the essential functions, features and attributes for each life stage of Pugnose Minnow. Habitat attributes from published literature, and habitat attributes recorded during recent Silver Shiner surveys (captured over the last 10 years or since 2002) have been combined to derive the habitat attributes required for the delineation of critical habitat (see text for a detailed description of categories).

			Habitat Attributes		
Life Stage	**Function**	**Feature(s)**	**Scientific Literature**	**Current Records**	**For Identification of Critical Habitat**
Spawning	Reproduction (spawning likely occurs May to June) Nursery	Slow moving areas of streams or slow moving side channels of larger rivers.	• Laboratory - Males selectively chose the underside of a large rock, although many other potential spawning surfaces were readily available indicating a preference to this type of substrate for spawning (Page and Johnston 1990)		• Appropriate horizontal surfaces
Juvenile (hatch to age 1)	Feeding Cover	Slow moving areas of streams or slow moving side channels of larger rivers.			• Same habitat as adults
Adult (from age 1 [onset of sexual maturity])	Feeding Cover	Slow moving areas of streams or slow moving side channels of larger rivers.	**Water depth** • Water depth was recorded between 0.5-1.5 m (Parker et al. 1987) **Turbidity** • Described as preferring clear water habitats (Gilbert and Bailey 1972; Scott and Crossman 1973; Trautman 1981) • High level of suspended solids, (maximum Secchi disc of approx. 10 cm) (Parker and McKee 1980) • Secchi depth at points of capture ranged from 0.1 – 0.3 m (ROM unpubl. data in COSEWIC draft) **Vegetation** • Vouchers captured from the North Sydenham River described habitat as weedy embayments (Parker and McKee 1980)	• Shallow water with depth ranging from 0.42 to 1.34 m (DFO, unpubl. data) • Turbidity was measured with either a Secchi disc (readings ranged from 0.28 to 1.8 m) or turbidity tube (readings ranged from 0.22 to 0.64 m) (DFO, unpubl. data) • Most sites were classified as being dominated by open water (n=8), while sites dominated by submergent (n=5) or	• Areas of shallow water, ranging from 0.42 to 1.5 m.

			Habitat Attributes		
Life Stage	Function	Feature(s)	Scientific Literature	Current Records	For Identification of Critical Habitat
			• Capture locations in Mitchell's Bay indicated aquatic vegetation was present, and heavy growth of spatterdock was noted at several sites of capture (Parker and McKee 1980)	floating (n=2) macrophytes were also quite common (DFO, unpubl. data) • Specimens recorded from Chenail Ecarte and Detroit River were associated with abundant vegetation (DFO, unpubl. data)	

records may differ from optimal habitat attributes as it is believed that Pugnose Minnow is occupying sub-optimal habitat in areas where optimal habitat is no longer available.

RESIDENCE

Residence is defined in SARA as a, "dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding, or hibernating". Residence is interpreted by DFO as being constructed by the organism. In the context of the above narrative description of habitat requirements during juvenile and adult life stages, Pugnose Minnow do not construct residences during their life cycle.

THREATS

A wide variety of threats negatively impact Pugnose Minnow across its range. Our knowledge of threat impacts on Pugnose Minnow populations is limited to general documentation, as there is a lack of threat-specific cause and effect information in the literature for this species. The threats thought to have the largest effect on the survival and persistence of Pugnose Minnow in Canada are related to turbidity and sediment loading, habitat alterations, and nutrient loading. Lesser threats that may be affecting the survival of Pugnose Minnow include altered coastal processes, invasive species, and incidental harvest. In Ontario rivers, numerous activities are known to negatively affect fish habitat; however, those most commonly linked to the destruction and degradation of Pugnose Minnow habitat relate to agricultural and urban development, and result in increased turbidity, sediment loading, and siltation, increased levels of contaminants and toxic substances, and increases in nutrient loading (SRRT 2001). River and lake shoreline modifications can lead to altered flow regimes and coastal processes resulting in the loss of Pugnose Minnow preferred habitat. It is important to note the threats discussed below may not always act independently on Pugnose Minnow populations; rather, one threat may directly affect another, or the interaction between two threats may introduce an interaction effect on Pugnose Minnow populations. It is difficult to quantify these interactions; therefore, each threat is discussed independently.

TURBIDITY AND SEDIMENT LOADING

Increased turbidity has been linked to a decrease in riparian zones, leading to decreased bank stability and increased erosion, as well as erosion from channelized stream segments and poorly constructed bridge crossings (Dextrase et al. 2003). The most likely source of suspended solid loadings resulting in increased turbidity in the Sydenham River was identified to be agriculture (SRRT 2001). It has been estimated that the Sydenham River watershed is now composed of approximately 85% agricultural cover, while prior to European settlement the composition was 30% swamp land and 70% forest (SCRCA 2009b). Although Lake St. Clair would be considered a clear system with relatively low turbidity, sediment loading from surrounding watersheds is a known threat for this water body.

The effects of sediment loading on aquatic environments include decreased water clarity, increased siltation, and may have a role in the selective transport of pollutants (COSEWIC 2012). Increased turbidity also limits light penetration in the water column, limiting the growth of aquatic vegetation. It has been suggested that turbid environments would likely reduce the effectiveness of the spawning males display behaviour; although, Pugnose Minnow reproductive behaviour (i.e., attach their eggs to the underside of rocks, or flat surfaces) may in fact protect

the eggs from increase siltation (COSEWIC 2012). Other effects of increased turbidity may include compromised respiration, decreases in visibility, and prey abundance (COSEWIC 2012).

Historically, Pugnose Minnow was described to avoid highly turbid or silted waters (Gilbert and Bailey 1972). This description was supported by Pflieger (1997) who stated that the largest populations of Pugnose Minnow in Missouri were found in clear areas. The majority of Pugnose Minnow recorded in Canada were captured in areas of high turbidity. Two possible explanations for these occurrences are that Pugnose Minnow have a tolerance for increased turbidity (although this may not be their preference), or that resulting from the destruction and unavailability of their preferred habitat, relict populations of Pugnose Minnow may persist for some time under sub-optimal conditions. As described in the Habitat Requirements section, this persistence in areas of sub-optimal habitat may be used to explain why few individuals have been captured in Canada despite concerted, targeted sampling efforts.

There is currently no information available related to the tolerance threshold of Pugnose Minnow for turbid environments. Research on tolerance thresholds could shed light on the contradictory descriptions of Pugnose Minnow preferred habitat and habitat in which Pugnose Minnow is currently found in Canada.

NUTRIENT LOADING

Nutrient loading has been identified as a primary threat affecting species at risk in the Sydenham River and in Lake St. Clair (SRRT 2001; Staton et al. 2003; SCRCA 2009b). Degradation of Pugnose Minnow preferred habitat may occur through increases in nutrient loading from manure and fertilizer applications to farmland leaching into waterbodies, sewage treatment outputs, and failing septic systems. In addition, improper agricultural practices, such as milkhouse water discharges, and livestock access to the river can cause increases in nutrient pollution (SCRCA 2009b). These increased nutrient levels can lead to the development of algal blooms and, consequently, to decreased levels of dissolved oxygen once the blooms begin to senesce (Bejankiwar 2009). Specifically, nutrient loading has been listed as a primary threat to the south shore of Lake St. Clair (SCRCA 2009b).

SCRCA (2009a) indicated that sewage treatment bypasses and combined sewer overflows can be discharged into local watercourses resulting in elevated nutrient levels and increased oxygen demand. In addition, the lack of proper maintenance, an aging system, and the discharge of poorly treated sewage from faulty septic system can be a significant source of pollutants (SCRCA 2009b). As reported in the Lake St. Clair Technical Report (SCRCA 2009b), the Ontario Ministry of Environment conducted a number of Clean Up Rural Beaches (CURB) studies, in which they identified the relative impact of pollution sources within the tributaries of the Lake St. Clair watershed. Results from the CURB study indicated that 65% of the pollution in Bear Creek, a tributary of Sydenham River, could be attributed to faulty septic systems. Faulty septic systems are listed as the largest bacterial pollution contributor (SCRCA 2009b). The second largest contributor was improper agriculture practices (manure spreading, cattle access, and runoff from manure storage). A study on the effects of livestock manure application methods on water quality conducted on the Thames River concluded that 2% of manure applied to silt loam fields moved to a watercourse through the field tiles (Wall et al. 1997).

The current water quality objective for total phosphorus concentration to prevent the growth of nuisance algae is 0.03 mg/L (OMOE 1994). The St. Clair Region Conservation Authority (SCRCA) recently completed watershed report cards for their region, which included a survey of surface water quality parameters (SCRCA 2008). These report cards incorporated water quality readings at various locations taken from 2001 to 2005. Pugnose Minnow is currently known to

occur in three of these watersheds (Lower North Sydenham, Lower East Sydenham and Lake St. Clair tributaries). The average total phosphorus concentration reported for these three watersheds were 0.15, 0.13, and 0.08 mg/L, respectively (SCRCA 2008). It should be noted that the authors believed these values to be artificially low because the lower reaches of the Sydenham River are at the same elevation as Lake St. Clair and, consequently backflow from the lake may dilute water monitoring samples (SCRCA 2008). These results are similar to earlier results reported through the Upper Great Lakes Connecting Chanel Study (Environment Canada 1988 as cited in SCRCA 2008), in which water quality parameters were based on data collected from 1984 and 1985 for six Lake St. Clair tributaries. In this study, the average phosphorus concentration ranged from 30 to 200 ug/L, well above the current water quality objective.

HABITAT ALTERATION

Physical loss of Pugnose Minnow habitat can occur through habitat modifications, resulting from agricultural, urban and shoreline development. Modifications can result in water course drainage and infilling, loss of aquatic vegetation, and lake and river shoreline hardening.

Agriculture is considered the predominant land use in the Sydenham River watershed (SCRCA 2009b). What was once the Great Enniskillen swamp, covering 22% of the watershed, has now been converted to agricultural lands and the remaining wetland areas account for less than 1% of the watershed (SCRCA 2009b). Agricultural developments have changed the landscape by modifying the hydrological network with the use extensive tile drainage, and by reducing the extent and quality of aquatic habitat (SCRCA 2009a). Channelization, which alters the natural meandering pattern of the waterway is apparent throughout the watershed (SRRT 2001). In addition, free access to the river by livestock has resulted in the destruction of important riparian habitat that may be used as cover, and a source of food for many fish species (COSEWIC 2012).

Natural coastal processes in aquatic systems are necessary to maintain a balance between sediment deposition and erosion, maintaining vegetated areas, and ultimately providing habitat for many fish species. In the Detroit River, shipping needs have resulted in the creation of shipping lanes, shoreline hardening to protect against ship wave erosion, and dredging, which has permanently altered the habitat and flow regime in this area (SCRCA 2009a). A large proportion of the Lake St. Clair shoreline has also been altered with the construction of marinas, and dredging for marina purposes.

Fluctuating water levels may have a negative effect on habitat availability for Pugnose Minnow. Pugnose Minnow is thought to rely on the vegetative shoreline habitat of many of the St. Clair tributaries. These tributaries are highly affected by water levels in St. Clair proper, as their elevation is very similar to lake level. Water level fluctuations, whether they are through climate change or water level regulation, may result in a downslope movement of the current shoreline (IJC 2012). This movement may result in a decrease in the area of habitat with complex vegetation, decreasing potential Pugnose Minnow habitat. The effects of water level fluctuations are currently unknown for Pugnose Minnow.

Although there is no quantitative information regarding the extent to which Pugnose Minnow is affected by human activities in Canada, loss of habitat, from a combination of shoreline development and the removal of littoral zone macrophytes, was credited for the extirpation of Pugnose Shiner (a closely related cyprinid with similar habitat requirements) from two Wisconsin lakes (Holm and Mandrak 2002). In the historic literature, Pugnose Minnow was often associated with high levels of aquatic macrophytes and riparian vegetation. It is likely that habitat alteration and loss is playing a role in the current status of Pugnose Minnow in this area.

CONTAMINANTS AND TOXIC SUBSTANCES

Southwestern Ontario experiences as many reported toxic spill events (fuel, oils, manure, chemicals, petroleum products) as does the rest of the province combined and represents a significant threat to the persistence of Pugnose Minnow populations (ECO 2002). During the period from 1988-1998, 229 manure spills were reported in southwestern Ontario, whereas, 274 were reported from the rest of Ontario (ECO 2002). Of the manure spills that resulted in large-scale fish die-offs (46 events), 85% occurred in southwestern Ontario (ECO 2002). Between 1988 and 2000 manure spills reportedly caused more fish kills in Ontario than all other types of spills (SCRCA 2009b).

Agricultural growth has contributed to an increase risk of manure spills, while urban development has contributed to increased discharge of other types of contaminants, such as salt and fertilizers. Toxic substances in the form of pesticides, commonly used for maintenance of golf courses, and urban areas can enter the watercourse with runoff.

The application of road salts as a de-icing or anti-icing chemical has been highlighted as an increasing area of concern for our lakes and streams (EC 2001). Road salts enter the surface water and groundwater after snow melt and can lead to the salinization of our lakes, rivers, and streams (Demers and Sage Jr. 1990). This type of chronic toxicity has been shown to particularly affect algae and benthic fauna, ultimately affecting fish populations (EC 2001). Currently, information on the chloride threshold for Pugnose Minnow is unknown, as is the frequency that Pugnose Minnow has been affected by catastrophic events, such as toxic spill events.

INVASIVE SPECIES

The introduction of invasive species, both fishes and aquatic vegetation, to areas where Pugnose Minnow is known to exist may have unfavorable effects on the local Pugnose Minnow population. An invasive species is a non-native species whose introduction does or is likely to cause environmental or ecological harm. The feeding behaviour of Common Carp (*Cyprinus carpio*) is known to have serious negative impacts on aquatic systems by uprooting aquatic vegetation and increasing turbidity levels (Lougheed et al. 1998; Lougheed et al. 2004). This feeding behaviour may have significant effects on Pugnose Minnow, which are thought to require aquatic vegetation for many of their life processes and are sensitive to turbidity. In addition, the presence of Round Goby (*Neogobius melanostomus*) and Tubenose Goby (*Proterorhinus marmoratus*) may negatively affect Pugnose Minnow by preying on Pugnose Minnow eggs. Although this predator behaviour has not been observed for Pugnose Minnow, Round Goby have been recorded to prey on the eggs of other native fish species (French and Jude 2001). In addition, as there is some evidence that Pugnose Minnow use the underside of large rocks to spawn (Page and Johnston 1990), dreissenid mussels (Zebra Mussel, *Dreissena polymorpha*; Quagga Mussel, *Dreissena rostriformis bugensis*) may foul spawning surfaces. The effect that other invasive fish and aquatic vegetation species may have on Pugnose Minnow populations is currently unknown.

INCIDENTAL HARVEST

Pugnose Minnow is not a legal baitfish due to its listing as a species of Special Concern (OMNR 2012). As with most fisheries, the potential for bycatch exists during angler and commercial baitfish harvest. Bycatch is dependent on the distribution and intensity of baitfish harvest in relation to the distribution of Pugnose Minnow. Bycatch of Pugnose Minnow during angler harvest of bait is currently unknown due to uncertain angler practices, but bycatch from

commercial harvest practices has been estimated (Drake and Mandrak 2012). A substantial portion of Ontario commercial harvest occurs in nearshore areas of lakes Huron, Erie, and Ontario where Pugnose Minnow does not occur. Commercial harvest also occurs in tributary streams of the Great Lakes, including those where Pugnose Minnow may be found. Generally, the rarity of the species implies that the potential for incidental harvest of Pugnose Minnow is low.

Should bycatch occur, the ability of harvesters to sort and remove Pugnose Minnow from target catches is unknown. However, a study of the Ontario baitfish pathway (Drake 2011) did not document any Pugnose Minnow during sampling of $n = 68$ baitfish purchases (a cumulative total of 16 886 fishes) in southern Ontario during August-October, 2007 and February 2008 (Drake 2011). The lack of Pugnose Minnow in baitfish purchases indicated that bycatch did not occur (i.e., sites containing Pugnose Minnow were avoided during harvest), or that Pugnose Minnow was captured as bycatch, but sorting at the harvest or retailer sites removed the species from catches prior to sale to the angler. Overall, these results indicate that the probability for incidental harvest is low.

CLIMATE CHANGE

Through discussion on the effects of climate change on Canadian fish populations, impacts such as increases in water and air temperatures, changes (decreases) in water levels, shortening of the duration of ice cover, increases in the frequency of extreme weather events, emergence of diseases, and shifts in predator-prey dynamics have been highlighted, all of which may negatively impact native fishes (Lemmen and Warren 2004). Doka *et al.* (2006) completed an assessment on the projected impacts of climate change on wetland fish assemblages by ranking fish species vulnerability to climate change. A vulnerability matrix was calculated and was based on species status, and thermal and habitat associations (Doka et al. 2006). Results indicated that, of the 99 fish species assessed, Pugnose Minnow was ranked as the most sensitive species.

Conversely, Chu et al. (2005) predicted a potential spread in the distribution of certain cyprinids (i.e., Pugnose Shiner) into more northern watersheds under climate change scenarios. However, Pugnose Minnow's high vulnerability to specific environmental conditions may limit its distribution.

Since the effects of climate change on Pugnose Minnow are highly speculative, it is difficult to determine the likelihood and impact of this threat on each Pugnose Minnow population; therefore, the threat of climate change is not included in the following population-specific threat level analysis.

THREAT LEVEL ASSESSMENT

To assess the Threat Level of Pugnose Minnow populations in Canada, each threat was ranked in terms of the Threat Likelihood and Threat Impact on a population basis (Tables 5-8). The Threat Likelihood was assigned as Known, Likely, Unlikely, or Unknown, and the Threat Impact was assigned as High, Medium, Low, or Unknown (Table 6). Threat Impact categorization is location specific, in that impact categorization was assigned on a location-by-location basis. If no information was available on the Threat Impact at a specific location, a precautionary approach was used - the highest level of impact from all sites was applied. The Threat Likelihood and Threat Impact for each population were subsequently combined in the Threat Level Matrix (Table 7) resulting in the final Threat Level for each location (Table 8).

The level of certainty associated with the Threat Impact assignment has been assessed and classified as: 1=causative studies; 2=correlative studies; and, 3=expert opinion.

Table 5. Definition of terms used to describe Threat Likelihood, Threat Impact and Certainty.

Term	Definition
Threat Likelihood	
Known (K)	This threat has been recorded to occur.
Likely (L)	There is a >50% chance of this threat occurring.
Unlikely (U)	There is a <50% chance of this threat occurring.
Unknown (UK)	There are no data or prior knowledge of this threat occurring.
Threat Impact	
High (H)	If threat was to occur, it would jeopardize the survival or recovery of this population.
Medium (M)	If threat was to occur, it would likely jeopardize the survival or recovery of this population.
Low (L)	If threat was to occur, it would be unlikely to jeopardize the survival or recovery of this population.
Unknown (UK)	There are no prior knowledge, literature or data to guide the assessment of the impact if it were to occur

Table 6. Threat Likelihood and Threat Impact of each Pugnose Minnow population in Canada. Certainty has been associated with Threat Impact (TI) based on the best available data. The Threat Likelihood was assigned as Known (K), Likely (L), Unlikely (U), or Unknown (UK), and the Threat Impact was assigned as High (H), Medium (M), Low (L), or Unknown (UK). Certainty (C) has been classified and is based on: 1=causative studies; 2=correlative studies; and 3=expert opinion. References (Ref) are provided.

	St. Clair and tributaries				Detroit River			
	TLH	TI	C	Ref	TLH	TI	C	Ref
Turbidity and sediment loading	K	H	3	4	L	M	3	5
Nutrient loading	K	H	3	1,2,3,6	K	M	3	5
Habitat alteration	K	H	3	2,3,4	K	H	3	3
Contaminants and toxic substances	K	H	3	1,2,7	K	H	3	8
Invasive species	K	L	3	11	K	L	3	11
Incidental harvest	U	L	1	9,10	U	L	1	9,10

References:

1. SCRCA (2008)
2. SCRCA (2009b)
3. SCRCA (2009a)
4. SRRT (2001)
5. Bejankiwar (2009)
6. Staton et al. (2003)
7. EC (2001)
8. EC (2010)
9. Drake and Mandrak (2012)
10. Drake (2011)
11. Pugnose Minnow Recovery Potential Assessment (1 November 2012) participants

Table 7. The Threat Level Matrix combines the Threat Likelihood and Threat Impact rankings to establish the Threat Level for each Pugnose Minnow population in Canada. The resulting Threat Level has been categorized as Low, Medium, High, or Unknown.

		Threat Impact			
		Low (L)	Medium (M)	High (H)	Unknown (UK)
Threat Likelihood	Known (K)	Low	Medium	High	Unknown
	Likely (L)	Low	Medium	High	Unknown
	Unlikely (U)	Low	Low	Medium	Unknown
	Unknown (UK)	Unknown	Unknown	Unknown	Unknown

Table 8. Threat Level for all Pugnose Minnow populations in Canada, resulting from an analysis of both the Threat Likelihood and Threat Impact. The number in brackets refers to the level of certainty with the Threat Impact. Certainty has been classified as: 1= causative studies; 2=correlative studies; and 3=expert opinion.

Threats	Lake St. Clair and tributaries	Detroit River
Turbidity and sediment loading	High (3)	Medium (3)
Nutrient loading	High (3)	Medium (3)
Habitat alteration	High (3)	High (3)
Contaminants and toxic substances	High (3)	High (3)
Invasive species	Low (3)	Low (3)
Incidental harvest	Low (1)	Low (1)

The Threat Level results were used to assess the overall effect each threat may have on Pugnose Minnow in Canada. Each threat was categorized in terms of both Spatial and Temporal Extent (Table 9). Spatial Extent was categorized as Widespread (threat is likely to affect a majority of Canadian Pugnose Minnow population)] or Local (threat is likely to not affect the majority of Canadian Pugnose Minnow populations). Temporal Extent was categorized as Chronic (threat that is likely to have a long-lasting, or re-occurring effect on a population) or Transient (threat that is likely to have a short-lived or non-recurring effect on a population).

Table 9. Overall effect of threats on Pugnose Minnow populations in Canada. Spatial extent was categorized as Widespread (threat is likely to affect a majority of Pugnose Minnow populations in Canada) or Local (threat is likely to not affect the majority of Pugnose Minnow populations in Canada). Temporal Extent was categorized as Chronic (threat that is likely to have a long-lasting, or re-occurring effect on a population) or Transient (threat that is likely to have a short-lived or non-recurring effect on a population).

Threat	Spatial Extent	Temporal Extent
Turbidity and sediment loading	Widespread	Chronic
Nutrient loading	Widespread	Chronic
Habitat alteration	Widespread	Chronic
Contaminants and toxic substances	Widespread	Chronic
Invasive species	Widespread	Chronic
Incidental harvest	Widespread	Transient

MITIGATIONS AND ALTERNATIVES

Threats to species survival and recovery can be reduced by implementing mitigation measures to reduce or eliminate potential harmful effects that could result from works or undertakings associated with projects, or activities in Pugnose Minnow habitat. Although currently recognized as a species of Special Concern in Schedule 1 of the SARA, prohibitions do not apply to Pugnose Minnow. In Ontario, the species is listed as Special Concern under the *Endangered Species Act 2007*, which necessitates the preparation of a formal provincial recovery strategy for Pugnose Minnow to manage the species and prevent further decline. Legislation exists to prevent the intentional harvest of Pugnose Minnow as bait; however, due to its morphological similarity to other cyprinids, it may be inadvertently taken. Pugnose Minnow has previously been identified and included in the Sydenham River recovery plan.

Within Pugnose Minnow habitat, a variety of works, undertakings, and activities have occurred that have directly or indirectly affected Pugnose Minnow habitat including: water crossings (e.g., bridges, culverts, open cut crossings); shoreline and streambank works (e.g., stabilization, infilling, retaining walls, riparian vegetation management); instream works (e.g., channel maintenance, restoration, modification, realignments, dredging, aquatic vegetation removal); the placement of structures in water (e.g., boat launches, docks, effluent outfalls, water intakes); and, water management activities (e.g., stormwater management, irrigation). Research has been completed summarizing the types of work, activity, or project that have been undertaken in habitat known to be occupied by Pugnose Minnow (Table 10). The DFO Program Activity Tracking for Habitat (PATH) database, as well as summary reports of fish habitat projects reviewed by partner agencies (e.g., conservation authorities), have been reviewed to estimate the number of projects that have occurred during the three-year period, 2009-2011. Approximately 44 projects or activities are indicated but likely do not represent a comprehensive list of activities that have occurred in these areas (Table 10). Some projects may not have been reported to partner agencies or DFO if they occurred under conditions of an Operational Statement. Of the projects identified, seven were completed under conditions of Operational Statements primarily for bridge maintenance and directional-drilling water crossings. Only two bank stabilization projects along the Detroit River were authorized under ss. 35(2) of the *Fisheries Act*.

Following review, the remaining projects were deemed low risk to fishes and fish habitat and were addressed through letters of advice with standard mitigation. Without appropriate mitigation, projects or activities occurring adjacent or close to these areas could have impacted Pugnose Minnow (e.g., increased turbidity or sedimentation from upstream channel works). Based on the assumption that historic and anticipated development pressures are likely to be similar, it is expected that comparable projects and activities will likely occur in Pugnose Minnow habitat in the future. There was an increased frequency of works in the categories of water crossings and the placement of structures in water (i.e., docks). Research also indicated that the primary project proponents were individual landowners.

As indicated in the Threat Analysis, numerous threats affecting Pugnose Minnow populations are related to habitat loss or degradation. Habitat-related threats to Pugnose Minnow have been linked to the Pathways of Effects developed by DFO Fish Habitat Management (FHM) (Table 10). DFO FHM has developed guidance on mitigation measures for 19 Pathways of Effects for the protection of aquatic species at risk in the Central and Arctic Region (Coker et al. 2010). This guidance should be referred to when considering mitigation and alternative strategies for habitat-related threats. At the present time, we are unaware of mitigation that would apply beyond what is included in the Pathways of Effects.

Table 10. Summary of works, projects and activities that have occurred during the period of August 2009 to August 2011 in areas known to be occupied by Pugnose Minnow. Threats known to be associated with these types of works, projects, and activities have been indicated by a checkmark. The number of works, projects, and activities associated with each Pugnose Minnow population, as determined from the project assessment analysis, has been provided. Applicable Pathways of Effects have been indicated for each threat associated with a work, project or activity (1 - Vegetation clearing; 2 – Grading; 3 –Excavation; 4 – Use of explosives; 5 – Use of industrial equipment; 6 – Cleaning or maintenance of bridges or other structures; 7 – Riparian planting; 8 – Streamside livestock grazing; 9 – Marine seismic surveys; 10 – Placement of material or structures in water; 11 – Dredging; 12 – Water extraction; 13 – Organic debris management; 14 – Wastewater management; 15 – Addition or removal of aquatic vegetation; 16 – Change in timing, duration and frequency of flow; 17 – Fish passage issues; 18 – Structure removal; 19 – Placement of marine finfish aquaculture site).

Work/Project/Activity	**Threats** (associated with work/project/activity)						**Watercourse/Waterbody** (number of works/projects/activities between 2009-2011)	
	Turbidity and sediment loading	**Nutrient loading**	**Habitat alterations**	**Contaminants & toxic substances**	**Invasive species**	**Incidental harvest**	**Detroit River**	**Lake St. Clair and tributaries**
Applicable pathways of effects for threat mitigation and project alternatives	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 15, 16, 18	1, 4, 7, 8, 11, 12, 13, 14, 15, 16	1, 2, 3, 4, 5, 7, 8, 10, 11, 12, 13, 14, 15, 16, 18	1, 4, 5 ,6 ,7 ,11 ,12 ,13 ,14, 15, 16 ,18				
Water crossings (e.g., bridges, culverts, open cut crossings)	✓			✓			1	15
Shoreline, streambank work (e.g., stabilization, infilling, retaining walls, riparian vegetation management)	✓			✓			6	1
Dams, barriers (e.g., maintenance, flow modification, hydro retrofits)	✓				✓			
Instream works (e.g., channel maintenance, restoration, modifications, realignments, dredging, aquatic vegetation removal)	✓	✓		✓			1	4
Water management (e.g., stormwater management,	✓	✓		✓				3

Work/Project/Activity	Threats (associated with work/project/activity)						Watercourse/Waterbody (number of works/projects/activities between 2009-2011)	
	Turbidity and sediment loading	Nutrient loading	Habitat alterations	Contaminants & toxic substances	Invasive species	Incidental harvest	Detroit River	Lake St. Clair and tributaries
water withdrawal)								
Structures in water (e.g., boat launches, docks, effluent outfalls, water intakes)	✓	✓		✓			11	2
Baitfishing						✓		
Invasive species introductions (authorized and unauthorized)					✓			

Additional mitigation and alternative measures, specific to the Pugnose Minnow, related to invasive species and incidental harvest are listed below.

INVASIVE SPECIES

As discussed in the **THREATS** section, aquatic invasive species (e.g., Common Carp) introduction and establishment could have negative effects on Pugnose Minnow populations. Mitigation and alternatives should not only be considered for current established invasive species but species that may invade in the future.

Mitigation

- Physically remove non-native species from areas known to be inhabited by Pugnose Minnow.
- Monitor watersheds for invasive species that may negatively affect Pugnose Minnow populations directly, or negatively affect Pugnose Minnow habitat.
- Develop a plan to address potential risks, impacts, and proposed actions if monitoring detects the arrival or establishment of an invasive species.
- Introduce a public awareness campaign and encourage the use of existing invasive species reporting systems.

Alternatives

- Unauthorized
    - None.
- Authorized
    - Use only native species.
    - Follow the National Code on Introductions and Transfers of Aquatic Organisms for all aquatic organism introductions (DFO 2003).

INCIDENTAL HARVEST

As discussed in the **THREATS** section, incidental harvest of Pugnose Minnow through the baitfish industry was recognized as a potentially low risk threat.

Mitigation

- Provide information and education to bait harvesters on Pugnose Minnow to raise awareness, and request the voluntary avoidance of areas occupied by Pugnose Minnow.
- Provide recommendations on timing windows as to when incidental harvest of Pugnose Minnow would have the greatest effect on the population (e.g., spawning season)
- Immediate release of Pugnose Minnow if incidentally caught, as defined under the Ontario Recreational Fishing Regulations (OMNR 2012).
- Education through mandatory training on species at risk for baitfish harvesters.

Alternatives

- Prohibit the harvest of baitfish in areas where Pugnose Minnow is known to exist.

If Pugnose Minnow is listed under the SARA, it is possible that alternatives in addition to mitigation may be required. However, alternatives, such as redesigning projects, have also been used as mitigations in many of the works that have taken place in the last few years. Offsetting may be required in some instances if future projects are permitted to result in the destruction of critical habitat.

SOURCES OF UNCERTAINTY

Despite concerted efforts to increase our knowledge of Pugnose Minnow in Canada (Mandrak et al. 2006; Marson and Mandrak 2009), there are still a number of key sources of uncertainty for this species related to population distribution and structure, habitat preferences and to the factors limiting their existence.

There is a need for a continuation of quantitative sampling of Pugnose Minnow in areas where it is known to occur to determine population size, current trajectory, and trends over time. There is also a need for additional targeted sampling in McDougall drain to confirm that this population is extirpated, as it is currently assessed as 'likely extirpated' in the population status assessment. Additional targeted sampling at known sites of capture should be completed to determine population sizes. Additional sampling is necessary for all populations that were assigned a low certainty in completing the population status assessment. These baseline data are required to monitor Pugnose Minnow distribution and population trends as well as the success of any recovery measures implemented. There is a need to explore novel sampling methods to capture Pugnose Minnow. Traditional sampling methods, seining netting, may not be appropriate for this species, and may help explain low capture numbers despite targeted efforts. If Pugnose Minnow can be successfully captured, there is a need to determine abundance estimates to properly interpret population modelling (see Young and Koops 2012). Certain life history characteristics, also required to inform Pugnose Minnow population modelling efforts, are currently unknown. Studies to validate age of maturation, growth, and longevity of Pugnose Minnow in Canada are required. Further studies should focus on acquiring additional information on fecundity, and population growth rate. Additional unknowns for this species include their ability to hybridize with other closely related species, and sex ratios.

Very little information is available regarding the habitat requirements of Pugnose Minnow in Canada. There is a need to identify habitat requirements for each life stage. Although it is currently assumed that individuals from all Pugnose Minnow life stages occupy the same functional habitat, this assumption should be verified through sampling. This may also allow us to gain a better understanding of preferred habitat of juvenile Pugnose Minnow. Larval surveys are needed to identify nursery grounds. Spawning habitat and spawning behavior of Canadian populations of Pugnose Minnow are not well known. It is difficult to infer the spawning season for Canadian populations of Pugnose Minnow based on the limited information available from populations found in the United States. Descriptions of Pugnose Minnow preferred habitat from the literature appear to contradict habitat descriptions recorded from areas where Pugnose Minnow has recently been captured in Canada (see Habitat Requirements section for additional information). The contradictory descriptions may be best explained by the theory that Pugnose Minnow in Canada are currently persisting in sub-optimal habitats because their preferred habitat has been lost to habitat degradation. This persistence in areas of sub-optimal habitat may also be used to explain why so few individuals have been captured despite concerted, targeted sampling efforts. There is a need to further investigate the relationship between the lack of population information, and the wider than expected range of habitat being used. It is important to determine expected Pugnose Minnow habitat for Canada to further inform targeted sampling.

Numerous threats have been identified for Pugnose Minnow populations in Canada, although the direct impact that these threats might have is currently unknown. There is a need for more causative studies to evaluate the direct impact of each threat on Pugnose Minnow populations with greater certainty. In the literature, the threat impacts are generally discussed at a broad level (i.e., fish assemblage level). There is a need to determine threshold levels for water quality parameters (e.g., nutrients, turbidity). The frequency and impact of toxic spill events on Pugnose

Minnow is an additional source of uncertainty. Also, the effect of invasive species, other than those discussed above, on Pugnose Minnow populations is currently unknown. Bycatch of Pugnose Minnow during angler harvest of bait is currently unknown due to uncertain angler practices. Should bycatch occur, the ability of harvesters to sort and remove Pugnose Minnow from target catches is unknown.

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